

Archaeomagnetic study of two medieval ovens discovered in the Pliska Palace, North-eastern Bulgaria

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ABSTRACT

Two dome ovens from the archaeological complex of Pliska Palace, North-Eastern Bulgaria, were sampled and studied using archaeomagnetic method. These two ovens are well dated archaeologically, and their archaeomagnetic results will elucidate better the sought geomagnetic field variations for the given time period. On the other hand, we have the possibility to demonstrate the applicability of the archaeomagnetic method for dating purposes. Detailed rock-magnetic analyses were performed in order to establish the magnetic properties of the collected materials (stability of carried remanence, type of dominant magnetic minerals, domain state of magnetic particles and degrees of mineralogical transformations during heating). In general, the investigated materials are suitable for archaeomagnetic determination. The applied experiments show that they have not been heated to temperatures over 460°C as the temperature of heating in oven No2 was probably slightly higher in comparison to that in oven No1. Taking into account the determined mean values for the geomagnetic field elements, it is obvious that both ovens have been used in the past within two different time periods. The mean declination of oven No1 is more than 20 degrees lower than the declination of oven No2. Differences between the two other geomagnetic field parameters, inclination and intensity, are less pronounced: 5 degrees for inclination and 3 μ T for intensity. An archaeomagnetic dating was done on the basis of Bulgarian reference curves from 2013. There is a very good agreement between the determined archaeomagnetic dating intervals (894–993) AD (for oven No1) and (1001–1075) AD (for oven No2), and the archaeological assumptions. These results confirm the importance of the archaeomagnetic method in archaeology as a reliable dating tool.

KEY WORDS

archaeomagnetism, archaeomagnetic dating, dome ovens, baked clay, Pliska Palace

Introduction

Archaeomagnetism is a geophysical method with a primary aim to recover the geomagnetic field variations in the past. At the same time, this method can be used as a reliable dating tool in archaeology. The Earth's magnetic field is defined by three elements. The first two, inclination (I) and declination (D), determine the geomagnetic field direction, while the third one, intensity (F), determines its absolute value. Archaeomagnetic methodology is based on the fact that baked clay materials acquire the so called thermoremanent magnetisation (TRM) when they cool down from high temperatures in a weak magnetic field (like the Earth's magnetic field). The TRM retains information about the geomagnetic field that has existed at the time and place of the last cooling. Investigations by archaeomagnetic

approach, of large amounts of well dated (by other methods) baked clay structures from different periods lead to the elaboration of the so called reference curves. These curves represent time variations of geomagnetic field characteristics (I, D, F) for particular area. If the curves are well established, they can be used for dating purposes (Kovacheva et al. 2004, 1463-1479; Kostadinova, Kovacheva 2008, 511-522). A great advantage of the existing Bulgarian reference curves is that they represent the longest local dataset in the world, covering almost fully the last 8000 years back to the Neolithic (Kovacheva 1980, 57-64; Kovacheva, Kanarchev 1986, 1297-1310; Kovacheva 1997, 145-151; Kovacheva et al. 1998, 413-460; Kovacheva et al. 2009, 1-6; Kovacheva et al. *in press*). Moreover the Bulgarian database includes simultaneous determination of the full geomagnetic field vector (D, I, F) obtained from one and the same material. In the countries where the variation only of intensity or of geomagnetic field direction is known, the archaeomagnetic dating should be performed on the basis of one or two elements. The most valuable materials for archaeomagnetic investigations are all kinds of baked clay remains found *in situ* because from such materials all geomagnetic field characteristics (inclination, declination and intensity) can be restored. From the displaced materials (e.g. pottery), only the absolute value of geomagnetic field intensity can be determined. In this case, any dating based on only one element is much more difficult and hence not well constrained. The gradual improvement of the local palaeosecular variations passes through inclusion of newly studied archaeological sites, well dated by other methods. The need to specify more precisely the geomagnetic field variations of the Middle Ages makes the archaeomagnetic study of the Pliska site a very important one.

Description of the samples

Samples for archaeomagnetic study were taken from two excavated dome ovens (oven No1 and oven No2) at the archaeological complex of Pliska Palace, North-eastern Bulgaria, in July 2012 from a team of the Palaeomagnetic Laboratory at the National Institute of Geophysics, Geodesy and Geography, BAS. Both ovens were situated in the eastern sector of the complex. Oven No1 belongs to dwelling XX-364/2 situated in horizon I and has probably been in use between 920 and 970 AD (Григоров 2012, 385, обр. 1, 386; Григоров, Занева, Тодорова 2013, 364, обр. 3). Oven No2 was found in dwelling XX-321/1a of horizon II which probably was built about 1000 AD and has been used for not more than 20-30 years (Григоров 2012, 385, обр. 1; Григоров, Занева, Тодорова 2013, 363, обр. 1). The collected samples were independently oriented using magnetic and sun compass, and were numbered 2573 to 2600 (Fig. 1). The sampled structures have been exposed for prolonged periods to the weather conditions. For this reason, the collected material was quite fragile and weathered. On the other hand the dome of oven No2, was still available, which additionally complicated the sampling procedure. That is why it was not possible to take a sun compass orientation for all gathered samples from oven No 2. The sun compass orientation is important as it allows the local magnetic anomalies to be avoided. Corrections for local magnetic anomalies in the samples without sun compass orientations were done using an average value from the corrections of the nearest samples. The floor plaster of oven No2 was more cracked and fragile in comparison to that of oven No1. Thus, many samples from this structure were disintegrated during the field work or transportation to the laboratory (Fig. 1). Overall, 32 samples were independently oriented (20 from oven No 1 and 12 from oven No2) but only 15 of them left for archaeomagnetic studies (11 from oven No1 and 4 from oven No2). All gathered pieces were initially impregnated with water glass in order

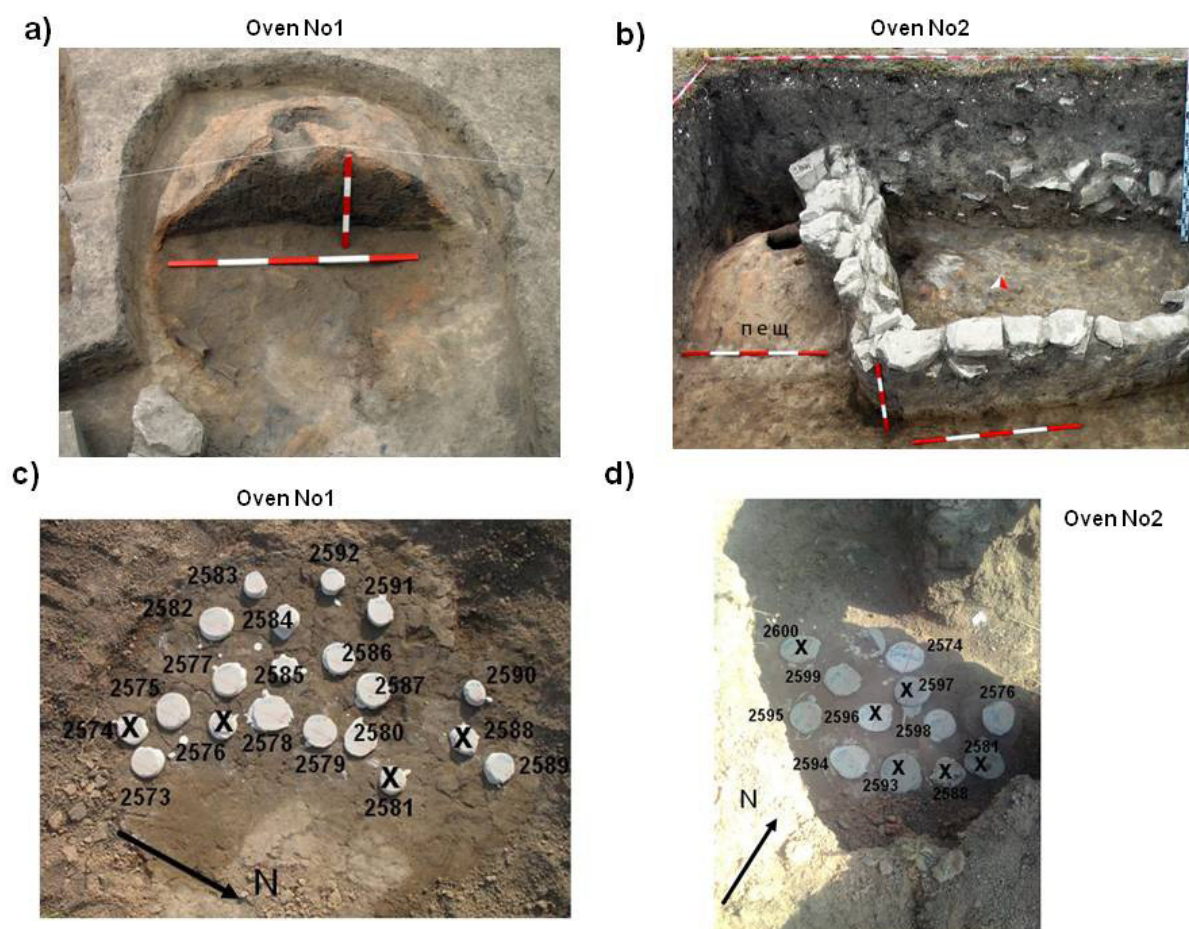


Fig. 1. Sampled ovens: a) and b) Pictures of ovens No1 and No2 respectively; c) and d) Distribution of the collected samples

Обр. 1. Опробвани пещи: а) и б) Снимки съответно на пещ No1 и No2; в) и г) Разпределение на събраните образци

to avoid disintegrations during cutting and laboratory procedures. Finally, 69 standard (8 cm³) cubic specimens were cut (52 from oven No1 and 17 from oven No2).

Methods and results

Each archaeomagnetic study performed at Sofia Palaeomagnetic Laboratory is accompanied by different rock-magnetic analyses in order to establish the magnetic properties of the gathered collections and to evaluate whether they are appropriate for the study. These analyses are quite important, because reliable archaeomagnetic determinations could be only obtained from materials which satisfied several conditions: 1) to carry stable thermoremanent magnetization; 2) to be consisted mainly of the so called single domain sized magnetic particles; and 3) their magnetic mineralogy to be stable during heating (not more than 10% of changes in the capacity of magnetization).

Usually the thermoremanent magnetization (TRM) acquired by the baked clays is sufficiently stable to keep the Earth's magnetic field direction (especially if TRM is induced by cooling down from temperatures of about 600°C). However, different factors affect the materials after TRM acquisition. Sometimes this can lead to formation of secondary remanences (usually viscous and less frequently chemical) that could be not parallel to the

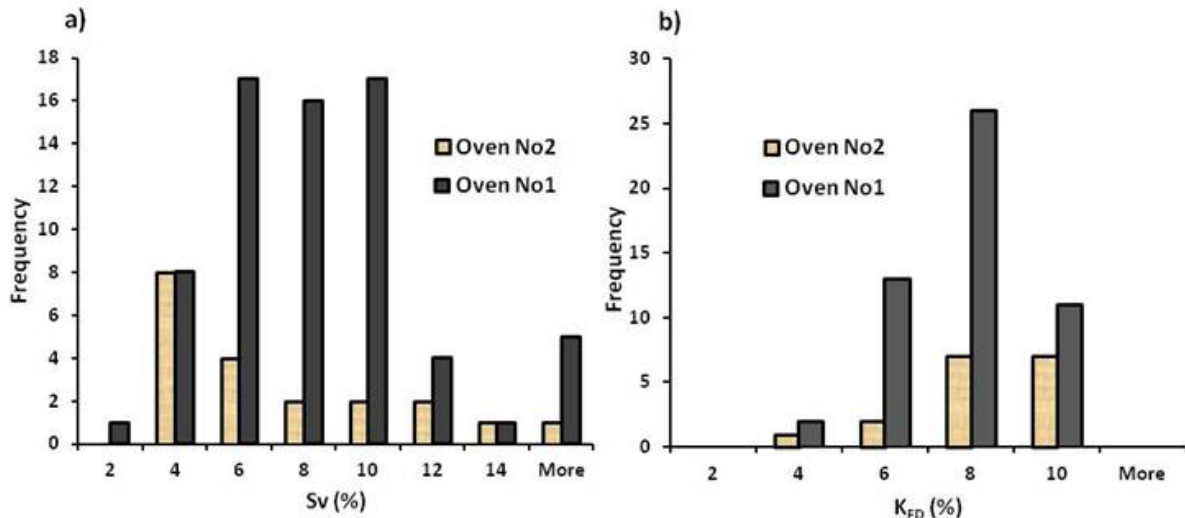


Fig. 2. Distribution of a) viscous coefficient (S_v) and b) frequency dependent magnetic susceptibility (K_{FD}) for oven No1 and oven No2

Обр. 2. Разпределение на а) коефициента на вискозност (S_v) и б) честотно-зависимата магнитна възприемчивост (K_{FD}) за пещ №1 и пещ №2

direction of the primary vector. Therefore, it becomes necessary to evaluate the stability of the carried remanence, and to remove secondary components by applying different kinds of magnetic cleanings as described below.

Viscous magnetic cleaning was performed for the whole collection in order to estimate the influence of the Earth's contemporary magnetic field. The specimens were left into mu-metal shielded boxes assuring a field-free space for a storage period of three weeks. After that the viscosity coefficient S_v (%) was calculated according to the relation: $S_v = \{NRM_0 - NRM_{st}\} / NRM_0 \times 100\%$, where NRM_0 is the initially measured remanence and NRM_{st} is the stable component measured after three-week zero field storage. It is considered that materials with S_v below 8% are appropriate for archaeomagnetic studies. The distribution of the obtained S_v values is shown on Fig 2a. It is obvious that this parameter often exceeds 8% (especially for samples of oven No1 – Fig. 2a) which means that the carried remanence is affected by a significant viscous component for many samples. The material coming from oven No1 is more viscous in comparison to that of oven No2. There are two possible explanations of the observed high S_v values – the presence of significant amount of fine unstable magnetic grains with superparamagnetic sizes in the materials, or insufficient heating of the studied structures in the past.

Frequency dependent magnetic susceptibility values (K_{FD}) are often used as an indicator of the relative amount of superparamagnetic particles in the materials. When K_{FD} values are higher than 6%, a significant amount of superparamagnetic particles can be assumed (Jordanova et al. 2001, 1138-1139). The measured K_{FD} values exceed 6 % (Fig. 2b) for almost all specimens studied herein.

Step-wise **thermal cleaning** was made for 31 specimens – 18 from oven No1 and 13 from oven No2. These specimens were progressively heated in a temperature interval of 80-700°C. This way their remanent magnetization was step-wise removed. The obtained stereographic plots and the so called Zijdeveld projections (Fig. 3a) provide information about the stability and the component content of the remanence carried. In most cases, the observed secondary viscous component was removed with heating between 80 and 300°C (Fig. 3a). Results are similar for both ovens.

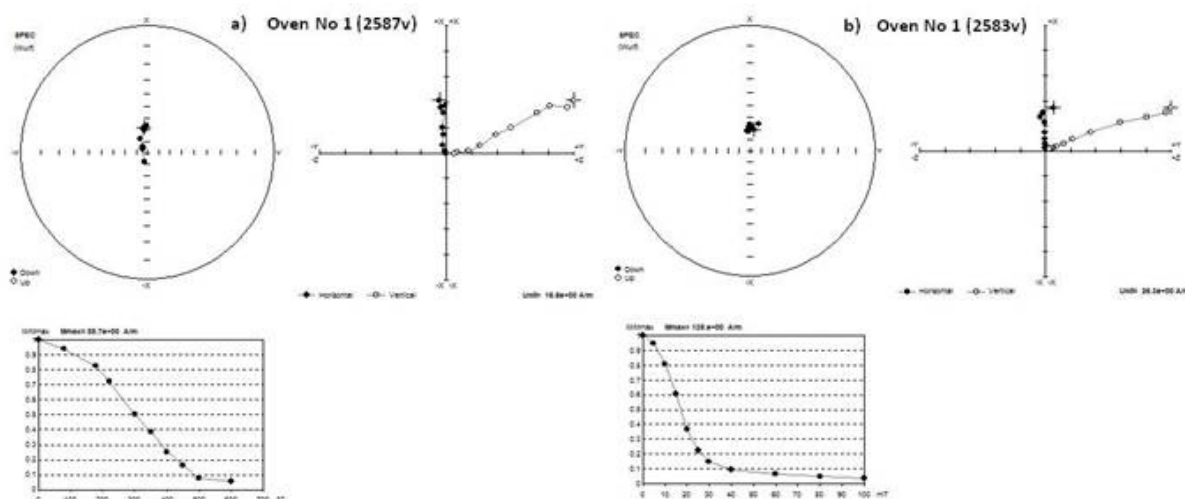


Fig. 3. Examples of magnetic cleanings using: a) temperature and b) alternating magnetic field.

Обр. 3. Примери за направени магнитни чистки посредством: а) температура и б) променливо магнитно поле

Step-wise demagnetization with alternating magnetic field up to 100mT (AF demagnetization) was applied on four pilot specimens from the studied ovens. The results are consistent with these obtained after thermal cleaning and confirm the presence of secondary viscous component (Fig. 3b). This component was removed after the third demagnetization step (15mT). With one exception, the remanence was completely demagnetized after the last step of the experiment (Fig. 3b) which indicates that low coercivity magnetic minerals (probably magnetite or maghemite) are dominant in the materials. However, the presence of high coercivity minerals (like hematite) in small quantities could not be excluded.

Two different methods were used to establish the dominant magnetic minerals in the studied structures – **3-axes IRM (3IRM) test** (Lowrie 1990, 159-162) and **thermomagnetic analysis**. The first method (3IRM test) represents a step-wise thermal demagnetization of three-component laboratory induced isothermal remanence (IRM) by three different field strengths. From the plotted demagnetization curves, the unblocking temperatures (T_c) and respectively the type of dominant magnetic minerals can be specified. The other method (thermomagnetic analysis) monitors the changes of magnetic susceptibility during heating, and provides a possibility to determine the Curie temperatures (T_c) of the main ferromagnetic minerals. Four specimens were subjected to the 3IRM test (two of oven No1 and two of oven No2). Thermomagnetic analyses were applied to five specimens (three of oven No1 and two of oven No2). Results from both experiments are in a good agreement and confirm that soft magnetic minerals are dominant in the clay used for the construction of the studied ovens. The identified T_b and T_c are typical for stable towards heating maghemite (Fig. 4) and titanomagnetite (Fig. 4c). The results of the thermomagnetic analysis performed for three of the investigated samples indicate a presence of hematite (Fig. 4b).

As mentioned above, the reliability of archaeomagnetic determination depends on the mineralogical stability of the materials during heating. Two experiments were used to evaluate the degree of mineralogical changes during heating – **thermomagnetic analyses and SIRM test** (Van Velzen, Zijderveld 1992, 79-90; Jordanova et al. 2003, 146-158). For both methods, the mutual position of two curves is determining. Heating and cooling curves measured during thermomagnetic analyses (Fig. 4b, c) are compared. If these curves are

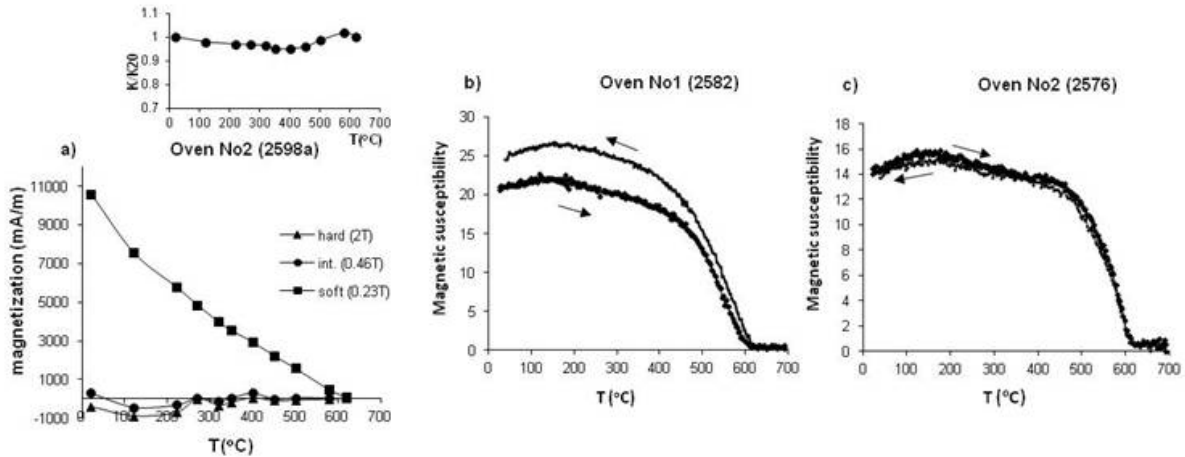


Fig. 4. Examples of: a) 3IRM test, b) and c) thermomagnetic analyses
Обр. 4. Примери за: а) 3IRM тест, б) и в) термомагнитен анализ

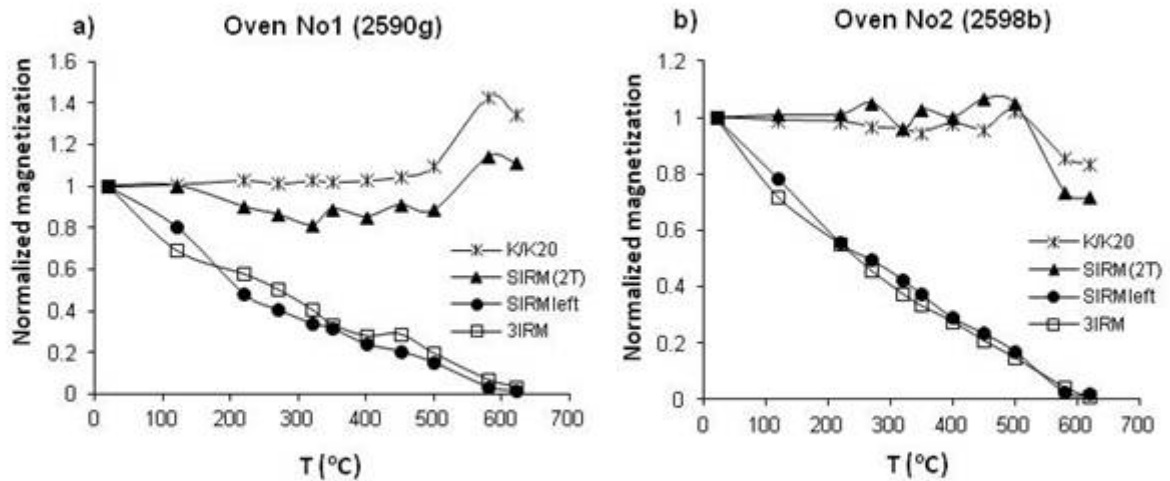


Fig.5. Examples of SIRM test: a) oven No1, and b) oven No2
Обр. 5. Примери за SIRM тест: а) печ No1 и б) печ No2

coinciding (e.g. reversible) then the changes in mineralogy can be considered as negligible (Fig. 4c). In the SIRM test, a comparison between 3IRM and SIRMleft curves (Fig. 5) is made. The module of isothermal magnetization from the 3IRM test is used. This magnetization is induced once in the laboratory, before heating. The second decay curve SIRMleft is the remaining part of laboratory induced saturated isothermal magnetization (SIRM) after each heating step. The possible mineralogical changes during the heating steps influence this second decay curve. If these two curves have similar patterns and coincide well, it can be concluded that the mineralogy is stable (Fig. 6). There are no contradictions between the results obtained by the thermomagnetic analysis and the SIRM test. It can be therefore considered that the mineralogical transformations during heating are negligible (much less than 10% change in the magnetic capacity).

During the 3IRM and SIRM tests, the magnetic susceptibility values (K) were measured at room temperature after each heating step and normalized to the initial value (K_{20}). The variations of K/K_{20} during heating also show the changes in magnetic capacity (Fig. 4a and Fig. 5 – the crosses). For all studied specimens K/K_{20} is almost constant up to 450-

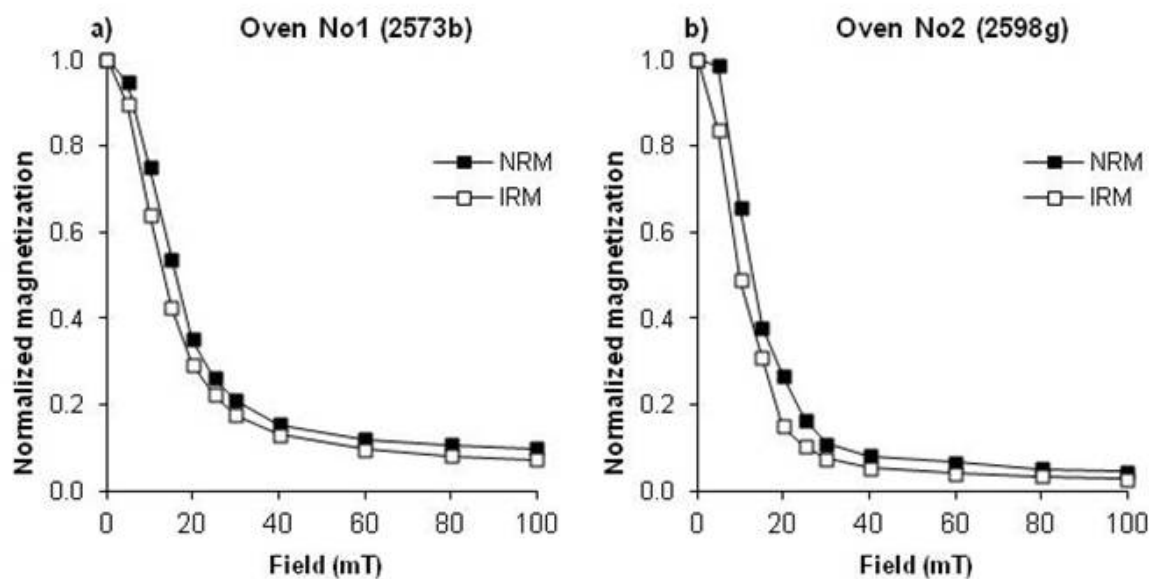


Fig. 6. Examples of single domain-like behaviour of ferromagnetic particles (Lowrie and Fuller test): a) oven No1, and b) oven No2.

Обр. 6. Примери за еднодоменно поведение на ферромагнитните частици (тест на Lowrie & Fuller): а) печ №1 и б) печ №2

500°C. Hence, the mineralogy is stable up to temperatures of this order.

Lowrie and Fuller test (1971, 6339-6349) was used to obtain information about the domain state of ferromagnetic particles. It should be noticed that this test is only applicable when the magnetite type minerals are dominant in the studied materials. In this specific case, a high coercivity mineral like hematite can be supposed only for one of the four investigated specimens (Fig. 6a) – about 10% of carried remanence (NRM) was left after the last demagnetizing step (100mT). The results from the Lowrie and Fuller test suggest that the thermoremanence is carried dominantly by the ferromagnetic particles with single domain sizes (Fig. 6a and b). This is especially favorable for obtaining good palaeointensity (PI) determinations.

The Coe variant (Coe, 1967a, b) of Thellier palaeointensity method (Thellier, Thellier 1959, 285-376) was applied to 12 specimens (6 from each oven). The method consists of successive step-wise double heating of the specimens in 14 incremental steps between 20 and 700°C (first heating is in a zero magnetic field, and the second – in the laboratory magnetic field $F_{lab}=65\mu T$). Three additional pTRM tests (Coe et al. 1978, 3247-3262) and three tail tests (Riisager, Riisager 2001, 111-117) were also performed. All the results were accepted which proves the suitability of the studied collection for palaeointensity determinations.

Magnetic susceptibility at room temperature was measured after each heating step as an indicator for the mineralogical changes during the PI experiment. For all studied specimens, the magnetic susceptibility changes started after 430-460°C (Fig. 7), and the linearity of Arai plots being compromised after these temperatures (Fig. 7). It can be concluded that the studied ovens have not been heated in the past to temperatures above 460°C as the temperatures reached in oven No2 have been probably slightly higher than those in oven No1. Thus, in temperature intervals used for palaeointensity determination T_{max} is 430 or 460°C (Table1). Consequently, the high S_v values established for the studied collections are due not only to the significant amount of superparamagnetic particles identified in the materi-

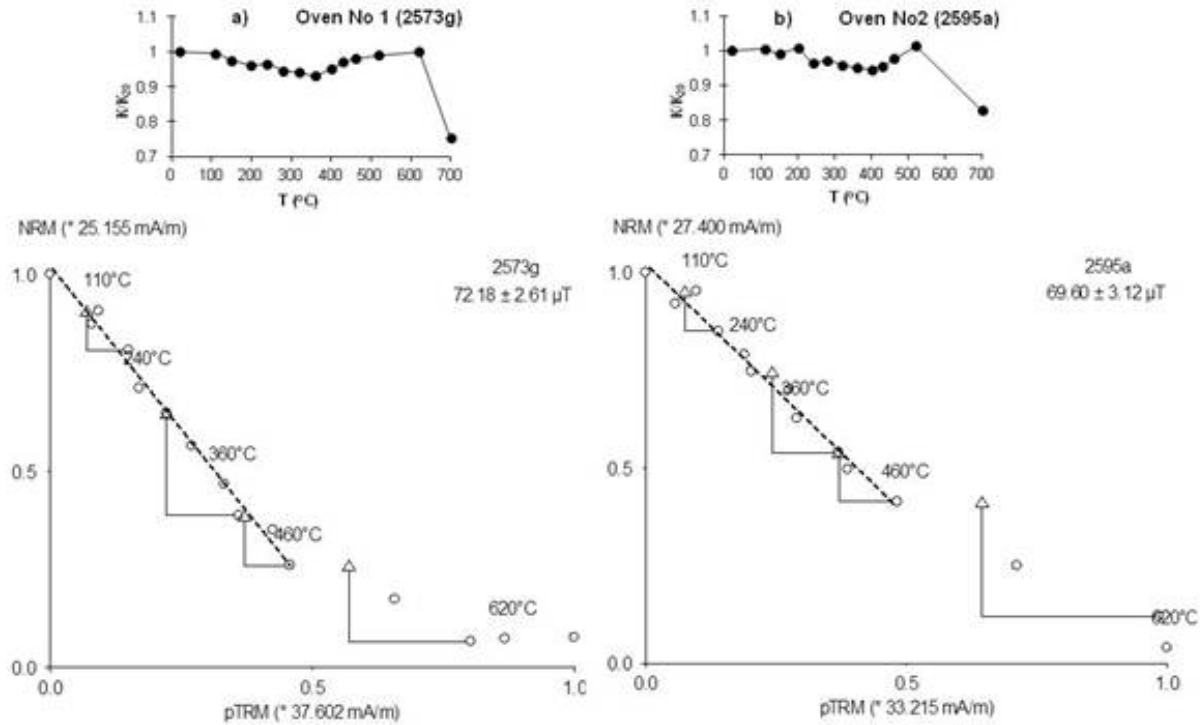


Fig. 7. Typical examples of palaeointensity experiments.

Обр. 7. Типични примери за резултати, получени при определянето на палеоинтензитета

als, but also to their insufficient heating in the past.

Discussion and archaeomagnetic dating

All laboratory experiments carried out indicate that the magnetic properties of the studied materials are appropriate for reliable archaeomagnetic determinations. The obtained results about the geomagnetic field elements (inclination, declination and intensity) are summarized in Table 1. The directional results are given in columns 2 and 3 (Table 1) where the declination values (D_{corr}) are given after applying a sun compass correction. The mean direction (I and D) of each independently oriented sample is calculated as an average of the values measured for the cut specimens after a corresponding cleaning (AF or thermal demagnetization). For five samples (four of oven No1 and one of oven No2), the directional results are discarded (Table 1) because of the unacceptable scattering between I and D values obtained from their sub-samples. The most probable reason for such a result is an insufficiently accurate orientation of these samples during the field work or errors during their cutting. For one sample coming from oven No2, the values of I and D (given in italic in Table 1) differ markedly from the others and are not taken into account for the final calculation of the direction. The mean direction of the corresponding oven is calculated according to the Fisher statistics (Fisher 1953, 295) over the averaged accepted directional values for all collected samples. The final archaeomagnetic determinations for the three geomagnetic filed elements are given in bold in Table 1 with their uncertainties:

- oven No1: $D=4.8^\circ$, $I=70.8^\circ$, $a_{95} = 2.3^\circ$ $Fa=73.80 \pm 3.04 \mu T$

- oven No2: $D=26.5^\circ$, $I=65.7^\circ$, $a_{95} = 2.7^\circ$ $Fa = 70.03 \pm 1.33 \mu T$

It is clear that the two investigated ovens from Pliska differ according to the obtained values of the geomagnetic field elements. Therefore, they have been used in two different

No	Dcorr (°)	I (°)	Fa (μT)	σ (μT)	T _{min} -T _{max}
Oven 1 (Labno 368)					
2573	9.6	70.6	72.18	2.61	20-460
2575	1.7	76.7			
2577	3.7	70	66.84	3.93	20-430
			75.12	3.38	20-460
2578		rejected			
2579		rejected			
2580	8.8	72.8	76.59	4.19	20-430
			75.28	2.95	20-460
2582	18.3	76.2			
2583	4.7	73.2			
2584		rejected			
2585		rejected			
2586	5.1	70.5			
2587	2.0	65			
2589	359.7	65.9			
2590	357.2	65	76.81	3.5	20-430
2591	6.2	70.6			
2592	8.1	72.6			
	4.8	70.8	73.80	3.04	N=6
	α ₉₅ =2.3	N=12			
	K=358				
Oven 2 (Labno 369)					
2574	24.41	65.6	69.37	2.83	20-460
2576		rejected			
2595	23.91	66.3	69.6	3.12	20-460
2598	8.51	71.4	68.25	3.03	20-460
2599	30.91	65	71.5	2.54	20-460
			71.71	3.08	20-460
			68.64	4.1	20-460
	26.5	65.7	70.03	1.33	N=6
	α ₉₅ =2.7	N=3			
	K=2156				

Table 1. Summarized archaeomagnetic results. No – sample` number; Dcorr – declination value after a sun compass correction (in degree); I – inclination value (in degree); α₉₅ – estimation of the error for direction (Fisher 1953); F – intensity value (in microtesla); σ – the corresponding error of intensity result (in microtesla); T_{min}-T_{max} – temperature interval used for intensity determination

Таблица 1. Археомангнитни резултати. No – номер на образца; Dcorr – стойности на деклинацията след поправка за слънчев компас (в градуси); I – стойности на инклинацията (в градуси); α₉₅ – оценка на грешката за получената посока (Fisher 1953); F – стойности на палеоинтензитета (в микротесли); σ – грешката, съответстваща на даден резултат за палеоинтензитета (в микротесли); T_{min}-T_{max} – температурен интервал, използван за определянето на палеоинтензитета

time periods in the past. The mean declination of oven No 1 is more than 20 degrees lower than the mean declination of oven No2 (Table 1). Differences in the other two parameters are smaller – approximately 5 degrees for the inclination, and 4 μT for the intensity (Table 1).

Archaeomagnetic dating is based on comparison of the obtained archaeomagnetic results with the corresponding reference curves representing the geomagnetic field variation for inclination, declination and intensity. After that, the determined dating intervals for each geomagnetic field element are combined and the most probable time period of the last usage of the studied structure is established. The precision of the performed archaeomagnetic dating is related to the accuracy of the experimental archaeomagnetic results obtained, and the accuracy of the reference curves used. This means that the application success of the archaeomagnetic approach depends largely on the reference points included in the database and also on the accuracy of their input dates. This dependence requires a constant update and improvement of each local database. In the present work, the archaeomagnetic dating corresponds to the reference curves from 2013. The last version of the REN-DATE-MODEL software (Lanos et al. in preparation) is used for dating. The final mean values of inclination, declination and intensity obtained for ovens No1 and No2 were consequently compared to the reference curves for the time interval (700 – 1500) AD – Fig. 8, Fig. 9. Each of these values (presented as a horizontal line) crosses the corresponding variation curve (of inclination, declination and intensity). Thus, several possible dating intervals were obtained (Fig. 8, Fig. 9). We have to find the interval in which the intervals from the three geomagnetic field elements overlap. In this manner, the possible dating interval for oven No1 is (894 – 993) AD (Fig. 10). This interval confirms the archaeological observations about the last moment of usage of oven No1 (Григоров 2012, 385, обр. 1, 386; Григоров, Занева, Тодорова 2013, 364, обр. 3). Three possible dating intervals were obtained for oven No2 (700-740) AD; (871 – 899) AD and (1001-1075) AD (Fig. 11). The multiplication of dating intervals is a result of the quasi-periodical character of the geomagnetic field elements variations. In such case, the archaeological evidence is determining. The first two dating intervals are completely unreliable according to the archaeological data (Григоров 2012, 385, обр. 1; Григоров, Занева, Тодорова 2013, 363, обр. 1). The latter interval, however, is in a very good agreement with the assumptions of the archaeologists. It should be noted that the Bulgarian reference curves in the time period related to the studied ovens from Pliska is still not well established. The included reference points concerning the last 2000 years are not enough for detailed clarification of the geomagnetic field variations. Moreover, the studied materials from many centuries are mainly bricks allowing determination of just two geomagnetic field elements: inclination and intensity. Despite this, the archaeomagnetic dating confirms the archaeological observations about the time of last usage of both studied ovens. This proves that the archaeomagnetism can be successfully applied as a reliable dating tool. The studied ovens from the Pliska Palace will be included as two new important reference points (Labnos 368 and 369) in the Bulgarian database, with dating based on the archaeological evidence only. The involvement of additional high quality archaeomagnetic data obtained from well dated (with other methods) archaeological baked clay structures will increase the accuracy of the archaeomagnetic dating method.

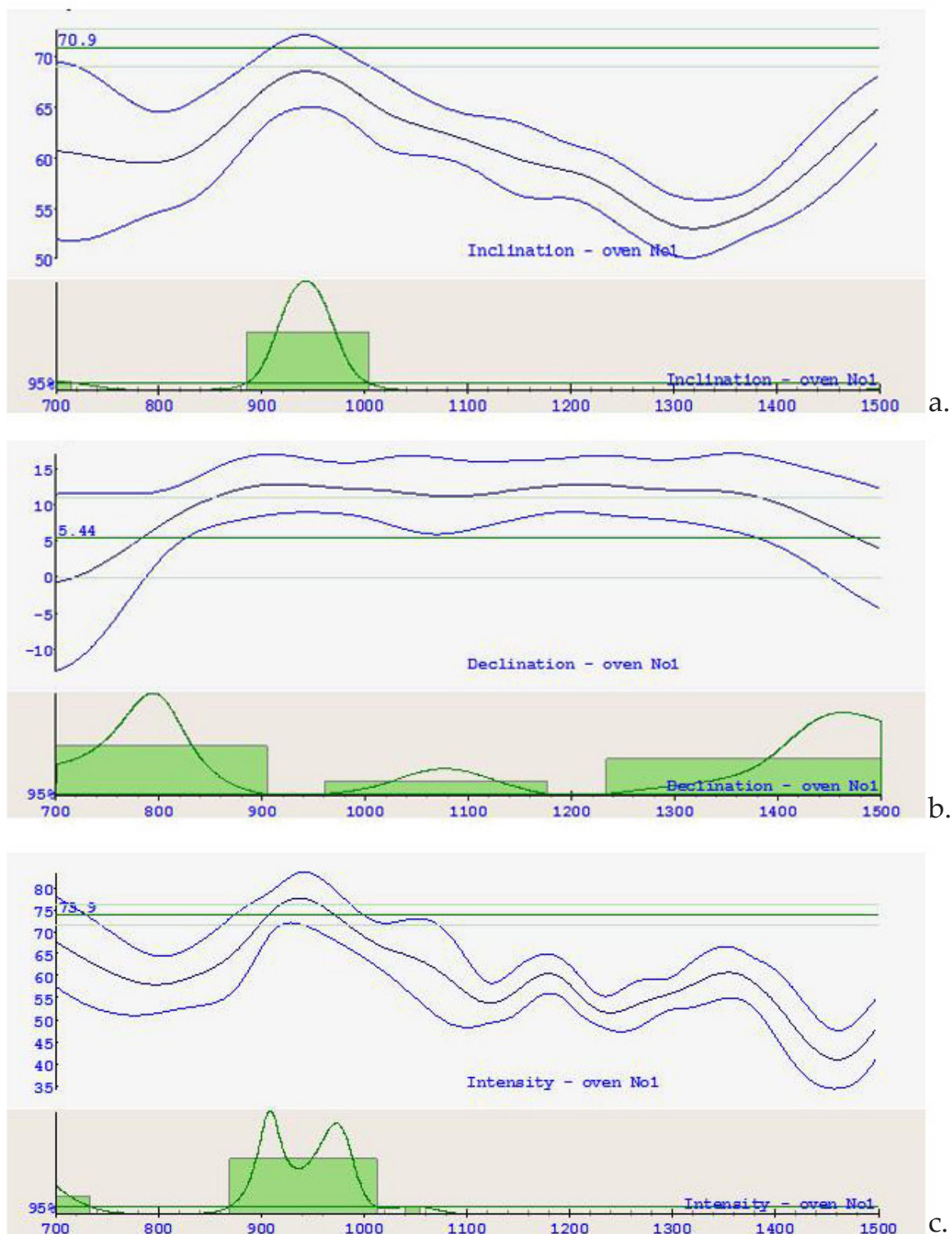


Fig. 8. Comparison of archaeomagnetic results obtained for oven No1: a) inclination, b) declination, and c) intensity with the corresponding Bulgarian reference curves.

Обр. 8. Сравнение на археомангнитните резултати, получени за пещ №1: а) инклинация, б) деклинация и в) интензитет със съответните реперни криви за България.

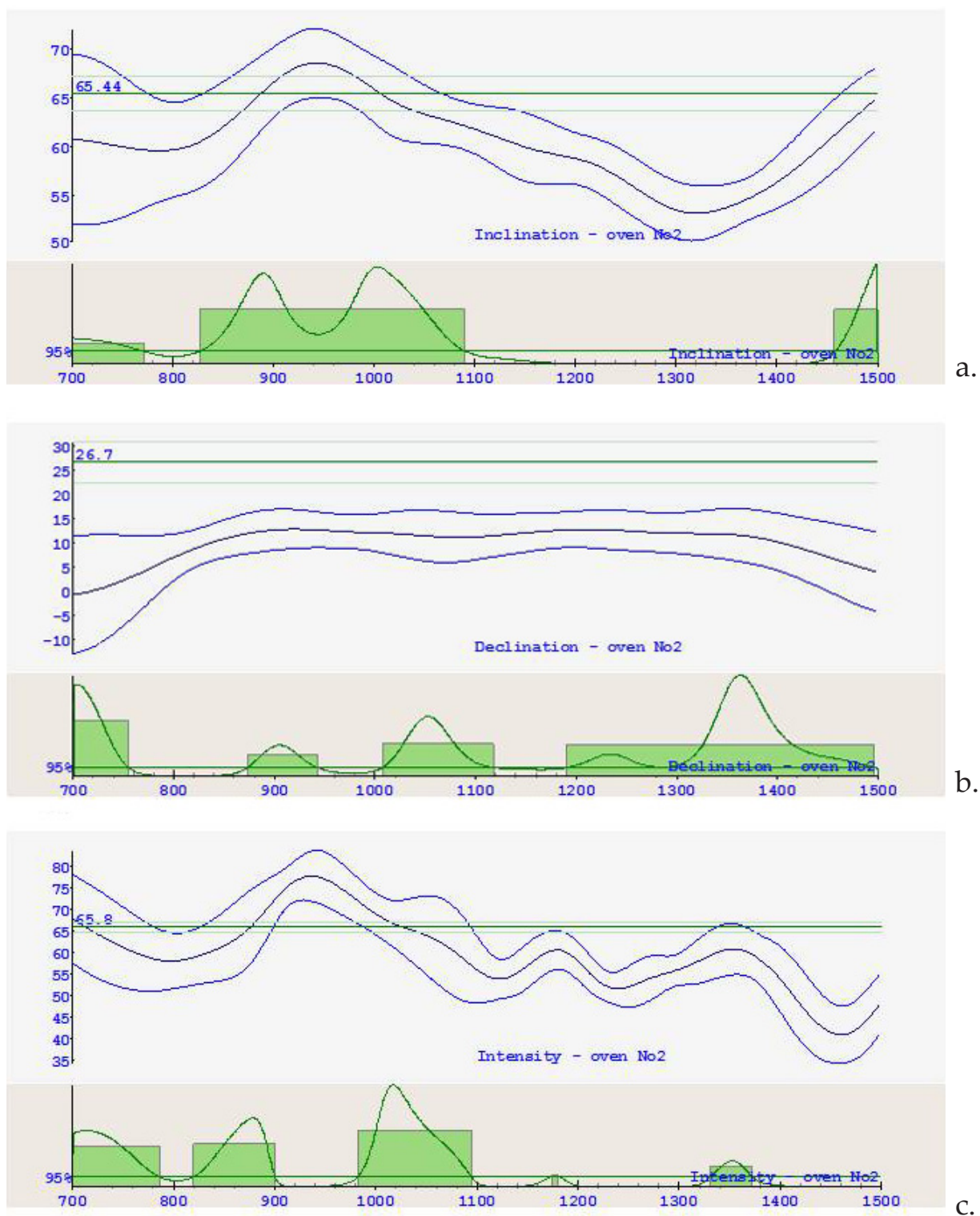


Fig. 9. Comparison of archaeomagnetic results obtained for oven No2: a) inclination, b) declination, and c) intensity with the corresponding Bulgarian reference curves

Обр. 9. Сравнение на археомагнитните резултати, получени за пещ №2: а) инклинация, б) деклинация и в) интензитет със съответните реперни криви за България

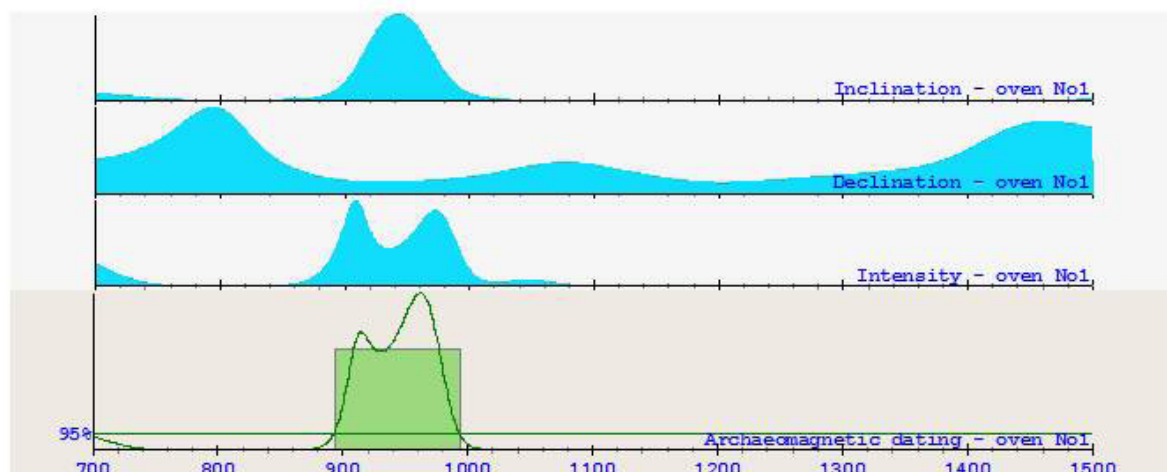


Fig. 10. Archaeomagnetic dating of oven No1 after the combination of the obtained dating intervals for inclination, declination and intensity. The final usage of oven No1 with 95% probability is in the time interval 894 – 993 AD

Обр. 10. Археоманитно датиране на пещ No1 след комбинация на получените датируеми интервали за инклинацията, деклинацията и интензитета. Пещ No 1 е била използвана за последен път във времеви интервал 894 – 993 AD (с 95% плътност на вероятността)

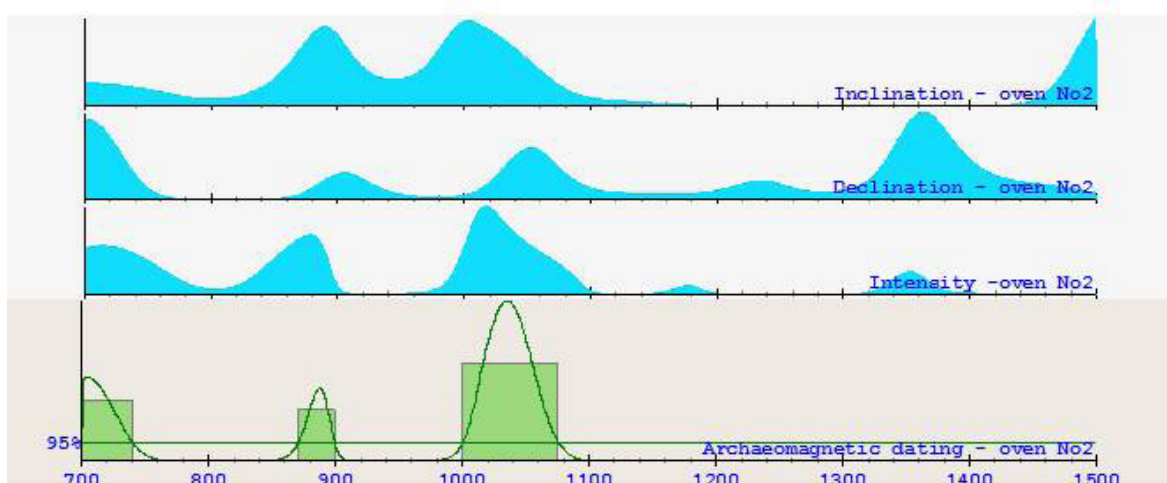


Fig. 11. Archaeomagnetic dating of oven No2 after combination of the dating interval obtained for inclination, declination, and intensity. Three possible time intervals, the first two being subsequently excluded on the basis of archaeological evidences: (700 – 740) AD; (871 – 899) AD; (1001 – 1075) AD. Thus, the final usage of oven No2, with 62% probability, is in the time interval (1001 – 1075) AD

Обр. 11. Археоманитно датиране на пещ No2 след комбинация на получените датируеми интервали за инклинацията, деклинацията и интензитета. Получени са три възможни датируеми интервали като първите два са неприемливи според археологическите данни: (700 – 740) AD; (871 – 899) AD; (1001 – 1075) AD. Следователно, последното използване на пещ No 2 е било най-вероятно във времеви интервал (1001 – 1075) AD (с 62% плътност на вероятността)

Conclusions

1. The detailed rock-magnetic experiments carried out show that the materials collected from ovens No1 and No2 at the Pliska Palace have suitable magnetic properties for archaeomagnetic study. Hence, reliable archaeomagnetic determination should be obtained from them.

2. The heating temperature in both of the studied ovens had not exceeded 460°C in the past. At the same time, oven No2 has been probably heated to a slightly higher temperature in comparison to oven No1.

3. The obtained archaeomagnetic determinations undoubtedly show that the investigated Pliska ovens have been last used in different periods.

4. The archaeomagnetic study of the investigated ovens gives reliable dating intervals of (894–993) AD for oven No1, and (1001–1075) AD for oven No2. These dating intervals agree very well with the archaeological observations.

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Археоманитно проучване на две средновековни пещи от Двореца в Плиска, Североизточна България

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(резюме)

Две пещи, разкрити на територията на дворцов комплекс Плиска, са опробвани и изследвани чрез археоманитния метод. Пещите са добре датирани археологически и получените по тях археоманитни резултати ще са от голяма полза за изясняването на вариациите на геомагнитното поле през разглеждания времеви период. От друга страна това е добра възможност за демонстриране на приложението на археоманитния метод за датирание. Направени са детайлни магнито-диагностични анализи, за да се установят магнитните свойства на събраните материали (стабилност на носената намагнитеност, вид на основните магнитни минерали, доменно състояние на магнитните частици и степен на минералогическите трансформации по време на грееене).

От получените резултати може да се заключи, че събраните образци са подходящи за археоманитно изследване и от тях могат да се получат достоверни археоманитни данни. Направените експерименти доказват без съмнение, че двете пещи не са били грят в древността до температури над 460 °C, като температурите, достигани в пещ No 2, вероятно са били малко по-високи в сравнение с тези, достигани в пещ No1. Средните стойности, получени за елементите на геомагнитното поле показват, че двете пещи са били използвани за последен път в различни моменти от време. Окончателната стойност, получена за деклинацията, е с около 20° по-ниска за пещ No1 в сравнение с тази за пещ No2. Разликите в другите два параметъра – инклинацията и интензитет, са по-слабо изразени – 5° за инклинацията и около 4 µT за интензитета. Археоманитното датирание е направено въз основа на българските реперни криви от 2013 г. Периодът от време, с който са свързани двете пещи от Плиска все още е недостатъчно добре изяснен. Въпреки това, получените археоманитни датирани интервали (894 – 993) г. н.е. за пещ No1 и (1001 – 1075) г. н.е. за пещ No2 се съгласуват добре с археологическите данни. Този резултат потвърждава приложимостта и важността на археоманетизма като метод за датирание в археологията.